

ABSTRACT

This report documents all continental tests from September 15, 1961, through September 23, 1992, from which radioactive effluents were released. The report includes both updated information previously published in the publicly available May 1990 report, DOE/NV-317, Radiological Effluents Released from Announced U.S. Continental Tests 1961 through 1988, and effluent release information on formerly unannounced tests.

General information provided for each test includes the date, time, location, type of test, sponsoring laboratory and/or agency or other sponsor, depth of burial, purpose, yield or yield range, extent of the release (onsite only or offsite), and category of release (detonation-time versus posttest operations). Where a test with simultaneous detonations is listed, location, depth of burial and yield information are given for each detonation if applicable, as well as the specific source of the release, if available.

A summary of each release incident by type of release is included. For a detonation-time release, the effluent curies are expressed at R+12 hours. For controlled releases from tunnel tests, the effluent curies are expressed at both time of release and at R+12 hours, if available. All other types are listed at the time of the release. In addition, a qualitative statement of the isotopes in the effluent is included for detonation-time and controlled releases, if available, and a quantitative listing is included for all other types.

Offsite release information includes the cloud direction, the maximum activity detected in the air offsite, the maximum gamma exposure rate detected offsite, the maximum iodine level detected offsite, and the maximum distance radiation was detected offsite. An explanation of how these categories are defined (for the purpose of this report) is found in the introductory text.

A release summary includes whatever other pertinent information is available for each release incident. This document includes effluent release information for 433 tests, some of which have simultaneous detonations. However, only 52 of these are designated as having offsite releases.

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INTRODUCTION

In May 1990, the U.S. Department of Energy (DOE) published the report Radiological Effluents Released from Announced U.S. Continental Tests, 1961 through 1988 (DOE/NV-317). The purpose of that report was to inform the public of all releases of radioactive effluent associated with the U.S. underground nuclear testing program. At that time, not all underground nuclear tests and none of the simultaneous detonations had been announced to the public; therefore, those release data could not be published.

In December 1993 and June 1994, the Secretary of Energy declassified information related to previously unannounced nuclear weapons tests and simultaneous detonations associated with nuclear weapons tests. This information also provided the definition (in language of the Threshold Test Ban Treaty) of a nuclear test conducted at the Nevada Test Site (NTS), and therefore differentiated a detonation from a test. A detonation is a single nuclear explosion, while a test can be a single or multiple nuclear explosion where specific parameters are defined in the treaty. The complete definitions are found in the Glossary of this report.

This revision of DOE/NV-317 provides information on the radiological releases of the previously unannounced tests and simultaneous detonations. In some instances, information has been updated for previously announced tests that had simultaneous detonations. Thirteen additional previously announced tests, not included in the May 1990 report, were determined to have released effluents upon further review of test data by the sponsoring laboratory. These tests have been included in this revision.

HISTORICAL AND BACKGROUND INFORMATION

The United States began testing nuclear explosive devices on July 16, 1945, near Alamogordo, New Mexico. Following the conclusion of World War II, the U.S. initiated several test series in the Pacific and, beginning in 1951, in the continental U.S. The U.S. entered into a unilateral testing moratorium on October 1, 1958. On September 15, 1961, the U.S. resumed testing. Prior to the moratorium, the majority of tests were conducted in the atmosphere. Following the resumption of U.S. nuclear testing, 824 nuclear tests have been conducted within the boundaries of the U.S. Most of these tests were detonated underground with the anticipation that radioactivity generated by these tests would be totally or largely contained within the earth's surface. This report describes all tests since 1961 that released radioactive effluent into the atmosphere. A compilation of all U.S. nuclear tests is contained in DOE/NV-209 (Rev. 14) United States Nuclear Tests, July 1945 through September 1992.

In 1992, the U.S. Congress imposed a moratorium on nuclear testing that has been maintained by the President. There have not been any nuclear tests conducted by the U.S. since September 1992. This report is a complete documentation of radioactive releases resulting from nuclear tests in the continental U.S. from 1961 through September 1992. Radioactive releases from underground nuclear tests prior to 1961 were insignificant when compared to the radioactivity released from atmospheric tests during that time period.

TEST RELEASE CATEGORIES

From September 15, 1961, through September 23, 1992, the DOE and its predecessor agencies conducted 824 nuclear tests at the NTS and other U.S. continental locations. All the tests were conducted underground except for those that were surface or near-surface tests. These included Plowshare cratering tests, Department of Defense (DoD) tests (Operation Sunbeam and others), and storage-transportation tests (Operation Roller Coaster).

During the period of nuclear testing before the Limited Test Ban Treaty (LTBT) was signed (i.e., from September 15, 1961, to August 5, 1963), no specific test containment design criteria existed. Therefore, while radioactive effluents released from underground tests conducted during this period were not always expected, any effluent releases that did occur were not considered accidental, or even unexpected. After August 5, 1963, when the LTBT was signed and design criteria had been formally established, all tests (except four Plowshare cratering tests) were designed to be completely contained underground. Of these 723 tests, only 105 were actual failures of containment design. Operational releases, such as those identified as controlled, drillback, gas sampling, mudpit or from cementback operations, occurred from 287 tests that included simultaneous detonations. There were also 32 operational releases from pre-LTBT tests. There were another five tests where late-time seepage occurred; these releases were considered neither accidental nor operational. Figure 1 shows a breakdown of the post-LTBT release categories. The numbers assigned to each of these categories account for multiple releases from some tests, and also reflect the numbers and categories from simultaneous detonations. The numbers also reflect the removal of one test (HAVARTI) that was reported in the initial DOE/NV-317 report published in May 1990. Upon further review by sponsoring-laboratory personnel, it was determined that no effluent was released from this test.

Very few of the tests or simultaneous detonations resulted in particulate release with accompanying fallout of radioactive material, and only 52 (i.e., 6.3 percent of the 824 tests conducted in this period) released radioactivity that was detected by ground or aerial measurements made offsite. This document summarizes each of those 433 tests, some of which have simultaneous detonations, where any type of release was detected. Figure 2 shows the offsite versus onsite release information.

RADIATION MONITORING

Onsite

For every test, ground monitoring onsite was performed by the laboratory or agency conducting the test. These include Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), Sandia National Laboratories (SNL), or the Defense Nuclear Agency (DNA) that is the testing organization within the DoD. In addition, Reynolds Electrical & Engineering Company, Incorporated (REECo), the onsite radiological support contractor, was responsible for operating the onsite monitoring equipment for every test.

For each test, radiation measurements began milliseconds after detonation, and continued until no apparent radiation hazard existed. If a release of radioactivity occurred, the first indications

of the occurrence, including the extent of the release and the direction the effluent was moving, were detections by the remote area monitoring system (RAMS). The RAMS consisted of an array of 30 to 40 permanent and a variable number of temporary (depending on the test) instrument stations that monitored gamma-ray exposure rates on the ground within the NTS.

Aerial monitoring was conducted onsite by REECo, the U.S. Air Force, the Environmental Protection Agency (EPA), and its predecessor, the Public Health Service (PHS). If a test release occurred, air support was available immediately to track the effluent in order to determine the size, radiation intensity levels, the rate of travel, and the trajectory of the cloud.

The onsite environmental monitoring program (where air, water, and external gamma exposure levels were constantly monitored) was conducted by REECo personnel. Air sample, thermoluminescent dosimeter (TLD), and water sample data were constantly analyzed to determine whether any increase in radiation levels occurred in a specific area because of delayed radiation releases.

Offsite

The EPA (or PHS) conducted the offsite ground monitoring program using gamma rate recorders, film badges or TLDs, air samplers, and portable monitoring equipment.

A network of over 100 permanent monitoring stations was established to maintain a continuous record of total radiation exposures outside the NTS. In addition, mobile monitoring units were deployed in the field depending upon the test and whether the effluent cloud trajectory was anticipated to travel offsite. Milk and water sampling stations were also established within a 300-mile radius of the NTS.

Offsite aerial monitoring and tracking operations were coordinated with onsite monitoring activities. After a detonation occurred, if effluent was detected by aircraft monitoring instruments, the EPA (or PHS) and the EG&G/EM Nevada Aerial Tracking System (NATS) were responsible for tracking the cloud and determining radiation intensity levels until no measurable radioactive effluent was detected.

RELEASE DESCRIPTION AND CLASSIFICATION

Each release has been categorized by type and has been defined for the purpose of this report. For some of the tests where multiple releases occurred, pertinent information on each release has been summarized, if available.

A "test" release (or an "uncontrolled" release for DoD tunnel tests) has been defined as a spontaneous release that occurred after a test but before postshot drilling operations began. This release definition also reflects the Containment Evaluation Panel (CEP) definition that states: "satisfactory containment will result in no radioactivity measurable offsite by normal monitoring equipment and no unanticipated release of radioactivity onsite." Therefore, test releases that did not meet the CEP definition were further categorized as pre-LTBT (i.e., before August 5, 1963), crater, surface, and near-surface tests. The pre-LTBT shaft and tunnel tests, where a sampling

conduit to the atmosphere was designed and placed in the test complex for sampling of the particulate matter released, have been defined as "test/prompt particle sampling" releases. The cratering Plowshare tests, where the test was designed to produce a throw-out of earth, have been designated as "test/crater" releases. Releases from surface tests have been categorized as "test/surface." Those surface and near-surface tests, that were non-nuclear tests designed to determine the extent of debris scattering, have been defined as "test/plutonium dispersal" releases. Test release quantity has been normalized to R+12 hours. This value represents the quantity of radioactive material remaining after decaying 12 hours from the time of release, and provides a measure of offsite exposure resulting from a radioactive release consisting of isotopes with widely varying half-lives. Values have been reported to two significant figures, and include a qualitative isotopic breakdown, if available.

"Controlled" releases were usually planned, filtered, tunnel-related releases. This type of postshot release was passed through a high efficiency, particulate air filter and charcoal filter combination where most of the particulates were removed from the escaping gases before these gases were vented from the tunnel into the atmosphere. Purging of the tunnels was required because health and safety considerations prevented reentry into the test area until airborne radiation levels were such that exposure to personnel would be minimal. Controlled releases also occurred from shaft tests, but these were infrequent. These data, listed at both time of release and at R+12 hours, if available, and estimated to two significant figures, reflect the effluent curies released to the atmosphere through the tunnel ventilation system. A qualitative isotopic breakdown is reported, if available.

"Drillback" releases occurred during postshot drilling operations to recover samples; these releases were either filtered or unfiltered. After drillback operations were completed, a "cementback" occurred where the drill hole was sealed with a plug and cemented to the surface. Releases during cementback operations were monitored by air sampling equipment. These release data have been listed at the time of release, estimated from the point of release and reported to two significant figures, when possible. A quantitative isotopic breakdown is reported, if available.

"Gas sampling" releases occurred during gas sampling operations, either before or after any postshot drilling operations commenced, depending on specific test circumstances. In most instances, these were controlled releases occurring when a determination had been made to reduce the volume of gas accumulated in a sampling tank. However, gas sampling releases also could have occurred as a result of equipment failure or other unexpected developments. These data have been listed in the same manner as drillback release data.

"Late-time seepage" releases occurred when noble gases have leaked from test sites after all operations in the area have ceased. These late-time releases were documented through the air sampling program that continually monitors radiation levels. This form of release is addressed in the NTS Environmental Impact Statement and is an anticipated phenomenon. These data have been reported in the same manner as drillback release data.

DATA FORMAT AND OFFSITE CATEGORY DESCRIPTIONS

The information listed below is given for each test in which a release occurred. However, for tests with simultaneous detonations, each individual detonation name, hole designation, depth of burial, and yield data are given, if applicable. If it is not known from which detonation the release occurred, all the detonation names that comprise the test are listed. Specific information includes the following items:

- The name, date, local time, and location (i.e., the Nevada Test Site or other continental locations, and the hole or tunnel designation).
- The type of test or simultaneous detonation (tunnel, shaft, crater, or surface).
- The extent of the release (i.e., whether the release was detected offsite or onsite only).

Special designation for onsite releases - Four tests, MINK, STOAT, HAYMAKER, and WICHITA, were designated to have had releases onsite only, even though after each of these tests, monitoring data indicated radioactivity in offsite areas. After further investigation, the DOE Test Authorities Liaison Office issued a memorandum on April 19, 1979, stating that these tests were not considered to have been detected offsite by the EPA. The reasoning for this determination was that at the time of these tests, weather data indicated that the prevailing wind directions made it extremely unlikely that radioactivity levels detected offsite were from any of these tests. More than likely, the source of the radioactivity detected was the result of foreign tests conducted during that time.

Qualitative onsite release data - Four tests, MAD, STILLWATER, CODSAW, and SACRAMENTO, are documented to have had "slight" test releases because monitoring techniques in use at that time did not provide quantitative release data. A reference document states that prior to October 1963, it is estimated that a total undetected release of up to 1,000 curies would be possible. This applies to volatiles and noble gases only, as undetected particulate releases would be much less. Subsequent to that time, undetected releases of up to five curies were possible.

- The laboratory and/or agency sponsoring the test. The acronym used denotes the name of the laboratory and/or agency at the time the test was conducted, i.e., LRL, LLL, LLNL, LASL, LANL, SC, SL, SNL, DoD, or laboratory acronym/UK. (See acronyms listing.)
- The depth of burial of the device(s).
- The purpose of the test or each of the detonations (i.e., weapons-related, weapons-effects, storage-transportation, Plowshare, Vela Uniform, safety experiment, or joint US-UK).
- The yield or yield range of the device(s), as listed in DOE/NV-209 (Rev. 14).

- The category of the release (i.e., test, operational [drillback, cementback, mudpit, and gas sampling], uncontrolled, controlled, late-time seepage, test/prompt particle sampling, test/crater, and test/surface).
- The data listed for releases detected offsite includes the following information, if available:

Isotopes identified in the release - a listing of the isotopes detected in the effluent released.

Cloud direction - the general direction and distance, if known, that EPA and/or NATS aircraft tracked the effluent cloud.

Maximum activity detected in air offsite - the geographical location and the data where the highest concentration of gross beta activity (expressed in picocuries per cubic meter of air; 1 picocurie = 1×10^{-12} curie) was detected. The samples were collected on air samplers (either at a permanent air sampling station or on a portable air sampler). These air samplers, strategically placed for a specific test, were fitted with glass fiber air filters and most had activated charcoal filters. Measurements were made at approximately one meter above ground level; this was considered to be the most accurate reading for a given location. Information is given for both populated and unpopulated areas, if available.

Maximum gamma exposure rate detected offsite - the geographical location and the data where the highest radiation exposure per unit of time was measured by a portable or stationary monitoring instrument. Measurements were made at approximately one meter above ground level.

Maximum iodine level detected offsite - the geographical location and the data where the highest concentration of iodine was measured in air by a monitoring instrument. The sample could have been collected on an air filter or an activated charcoal filter fitted on a permanent or mobile air sampler. Measurements were made at approximately one meter above ground level.

Maximum distance radiation detected offsite - the geographical location and the data at the greatest distance from the detonation where radiation was detected as measured by ground monitoring (i.e., radiation detection instruments, fallout trays, film badges, air samplers, or TLDs) or by aerial monitoring (i.e., data recorded on monitoring instruments in aircraft while tracking an effluent cloud).

- Quantitative isotopic information for operational releases, if available.
- A detailed release summary description, if available. This could include, but is not limited to, test venting information (both onsite and offsite); milk contamination as a result of fallout entering the food chain pathway (offsite); and operational postshot information (both onsite and offsite).
- Reference codes listed for each test identify information sources.

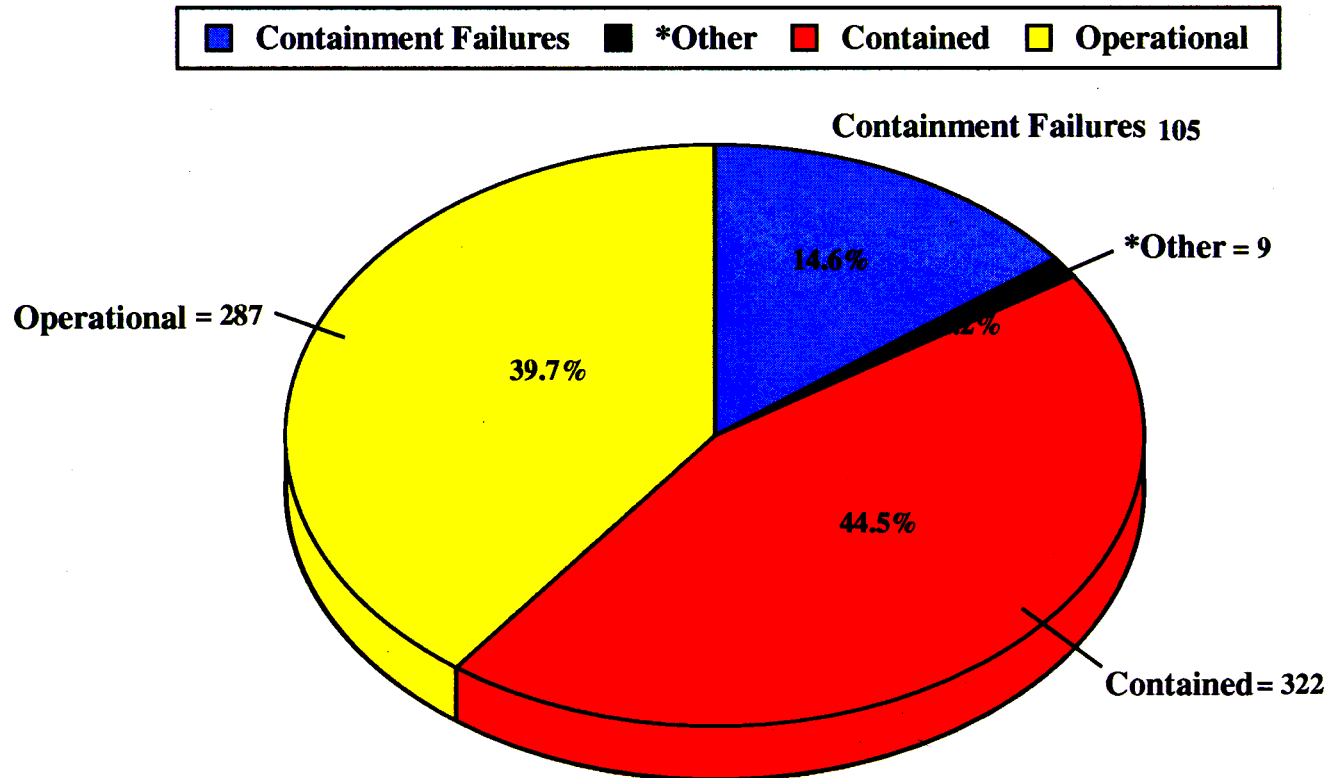
DOCUMENTATION

This report was compiled from the best information currently available. It has been reviewed by health and safety personnel from the DOE Nevada Operations Office (DOE/NV), the national laboratories, the Environmental Monitoring Systems Laboratory of the EPA, and DNA. Sometimes there are discrepancies between information compiled at different times by different individuals in estimating the magnitude of radiological releases; reporting yields and yield ranges; and detecting effluent releases at offsite locations. Source documents do vary, and therefore, some data found in this report may not agree with other DOE-published test data. This report reflects data referenced in this document and represents the current consensus of opinion of the subject matter experts from the above-mentioned agencies/laboratories.

All references, designated by an alphanumeric coding system appearing after each test summary, are listed in reference code order following the tests section of the report. Those references that are publicly available are denoted by an asterisk (*) following the citation. The classification of other references, if known, is denoted by the information within the brackets following the citation. All publicly available reference information can be obtained by contacting the DOE/NV Public Reading Facility, 2621 Losee Road, North Las Vegas, Nevada 89030. In addition, a glossary of terms, as they relate to this report, and a list of acronyms can be found after the reference information.

RELEASE CATEGORIES FOR TESTS CONDUCTED AT THE NTS AND OTHER CONTINENTAL LOCATIONS AFTER THE LIMITED TEST BAN TREATY (LTBT)

Total Tests Conducted Post-LTBT = 723



*Indicates late-time seepage and Plowshare/cratering

Figure 1. Release categories.

TEST RELEASE - OFFSITE VERSUS ONSITE 1961 -1992

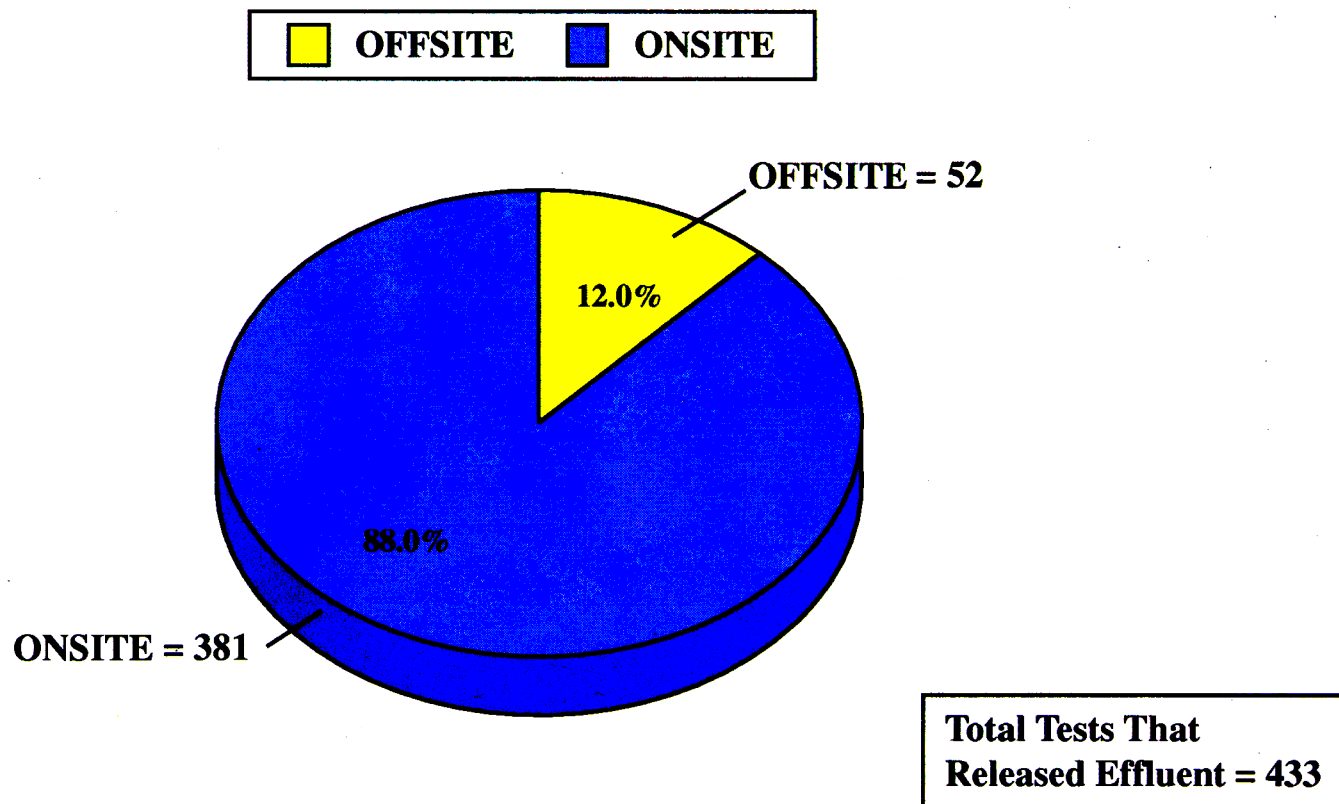


Figure 2. Offsite versus onsite releases.